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Fatty Acid Composition of Flax Sprouts

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Abstract

The oil and fatty acid profile of flax (*Linum usitatissimum*) sprouts and seed were compared to determine nutrition potential of sprouts. Equal quantities of seed from three flax cultivars (Rahab-94, Pembina and Linott) were sprouted twice in three replications and were analysed for oil and fatty acid contents during summer 2011. Three flax cultivars were observed with high oil content on dry weight basis in sprouts (15.9%) and seeds (33.99%). Significant variations (P<0.0001) between seed and sprout values for contents of unsaturated, polyunsaturated (UFA, PUFA) and saturated (SFA) fatty acids (P=0.0002) and non-significant (P>0.05) variation among three cultivars was observed. The percentage of PUFAs in cultivars Pembina and Linott was 68.7 and in Rahab-94 was 67.7. The percentage of linoleic acid (C18:2) was significantly high in sprouts (19.51%) compared to seed (17.7%). The percentage of linolenic acid (18:3) was high in seed (52.8%) compared to sprouts (48.8%). The ratio of PUFA/SFA in sprouts was high in Pembina (6.97%) and Linott (6.82%) compared to Rahab-94 (6.38%). The fatty acid profile was similar in all the three cultivars with significant (P<0.0001) reduction (<1%) in PUFA/SFA ratio of sprouts compared to seed (7.4%). Flax sprouts are equally potential to seed for viable natural resources of essential fatty acids (18:2 and 18:3).

Keywords: *Linum usitatissimum*, oil, MUFA, PUFA, SFA

1. Introduction

Flax (*Linum usitatissimum*), belongs to family Linaceae. *Linum* species were highly adapted to North America (Sivinski & Howard, 2011). Dietary fatty acids (Omega 3 and 6) were important for human growth, health and disease (Deckelbaum & Torrejon, 2012) and a sustainable plant resource is vital for dietary needs. Flax seeds are a good source of essential fatty acids (Omega 3 and 6), lipids, essential amino acids, lignans, and pigments (Oomah, 2001; Westcott & Muir, 2003; Herchi et al., 2011).

Flax is the potential resource to enrich human diet as ground seed (Bhardwaj et al., 2011) with essential nutrients in sprouts (Narina et al., 2012). The sprouting potential and nutritional values were identified viable in canola (Bhardwaj & Hamama, 2009), lupin (Hamama & Bhardwaj, 2004; Bhardwaj & Hamama, 2012), soybean (Dhakal et al., 2012). The soybean sprouts were high in quantities for genestein and diadzein compared to seed contents, besides appreciable quantities of essential fatty acids and bioactive compounds required for human nutrition (Marton et al., 2010; Orhan et al., 2007).

The amount of triglycerides, free fatty acids (FFA), phospholipids and the fatty acid compositions were determined in flax seed and an increase in FFA and linolenic acid in the phospholipids with germination were observed (Zimmerman & Klosterman, 1965). A report on fatty acid (FA) composition of flaxseed revealed Omega 3 / Omega 6 ratio of 4:1 was higher than the ratio (1:2) required for humans (www.curezone.com).

Cultivar variations for sprout quality were significant for unsaturated fatty acid and oil contents of soybean and Canola (Dhakal et al., 2012; Bhardwaj & Hamama, 2009). Significantly high ratio of 18:2/18:3 was observed in sprouts of Virginia cultivar of Canola (Bhardwaj & Hamama, 2009). Seeds of sesame were high for contents of oleic and linoleic acids (80-85%) compared to palmitic and stearic acid (Biglari et al., 2012).

Flax sprouts were reported with 22.3% protein, 17.0% crude fiber and 8.1% total sugars on dry weight basis (Narina et al., 2012). There were no reports to date on fatty acid composition of flax sprouts.Therefore, our objective is to analyze the oil content and fatty acid profiles for both flaxseed and sprouts of three cultivars and compare those values with other related crop seed sprouts like Canola and soybean.

2. Materials and Methods

Three flax cultivars (Rahab-94, Pembina and Linott) from germplasm collections of the New Crops Program were grown at the Randolph farm at VSU-ARS, Petersburg, VA. The matured seed from these three cultivars was used for raising sprouts. The sprout experiment was replicated thrice with three cultivars and conducted twice during 2011. An ample quantity of sprout was achieved for analysis from six biological sample replicates of six grams in each variety. The standard laboratory procedures (Narina et al., 2012) were used to raise sprouts from the seeds of three flax cultivars. The sprouts were harvested on the fourth day and were immediately freeze dried and stored in -80 degrees for further biochemical analysis.

The fine ground powder of freeze dried sprouts and seeds of the three cultivars were used to determine oil contents (gram/100g dry weight basis) and fatty acid composition (wt % of total fatty acids) using previously published protocols (Bhardwaj & Hamama, 2009). The chemicals and reagents used for analysis were HPLC grade and were obtained from Sigma-Aldrich Corporation (St. Louis, MO, USA) and Fisher Scientific (Pittsburgh, PA).

2.1 Statistical Analysis

Analysis of variance procedures (PROC GLM) in version 9.3 of SAS (SAS, 2012) were used to analyze the data generated. The sprout nutrient data was compared with those of seed and other related new crop sprouts (Table 2) to determine the potential of flax sprouts for nutritional values.

3. Results and Discussion

The average fresh sprout yield was 28.27 g from six grams seed. There were no significant differences observed among the three cultivars for major fatty acid (FA) and oil contents analyzed (Table 1). The oil content of sprouts (15.9%) was significantly low to that of seed (33.9%). The seeds are with very low water content compared to sprouts with high water content asthe process of germination will change the triglycerides composition to hydrolysis free fatty acids like linoleic acid (Marton et al., 2010). Most of the oil lost from seed was used as energy necessary for the growth of sprout (Orhan et al., 2007; Bhardwaj & Hamama, 2009).

The major FA composition for three cultivars was expressed as percentage of total fatty acid (Table 1). These FAs are classified into three main categories saturated (SFA-16:0, 18:0, 20:0 and 22:0), monounsaturated (MUFA-18:1, oleic and 20:1, eicasanoic) and polyunsaturated fatty acids (PUFA-18:2, linoleic and 18:3, linolenic acid).

There were non significant differences among three cultivars for saturated or unsaturated fatty acid contents. We observed non-significant variations (P=0.07) for polyunsaturated fatty acids (18:2 and 18:3) and monounsaturated fatty acids (18:1 and 20:1) for seed and sprout values. The variety Pembina was with high contents of 18:3 (49.6%) and Rahab-94 was with 18:2 (20%), were significantly different from Linott at 7% level of significance. The monounsaturated fatty acids were relatively similar in seed and sprout (20% oleic and 0.22% eicosanoic acid**)** values of all the cultivars. These results indicate that the sprout could be as viable as ground seed to provide equal quantities of fatty acids and could impact human health by protecting against cardiovascular diseases (Bhardwaj et al., 2012) or osteoporosis in humans (Orhan et al., 2007).

The saturated and unsaturated fatty acid compositions of sprouts (10.2% and 89.1%) were significantly different ($0.0002<P<0.0001$) from those of seed (9.5% and 90.4%). The present investigation revealed highest levels of UFAs in sprouts (89.1%) due to high levels of antioxidants that help to protect humans from oxidative stress (Lampi et al., 2002; Orhan et al., 2007). Similar findings were reportedin sprouts of soybean (Orhan et al., 2007) and flax (Narina et al., 2012) with significant amount and number of anti-oxidants.

Significantly high levels of total PUFAs (68.31% on dry weight basis) were observed in sprouts and were relatively similar in all the cultivars. Approximately 100 g of fresh sprouts were yielding 23.41 g of dry sprouts. Therefore, an amount 427.21 g of fresh sprouts required to get 68.31 mg of PUFA or 15.99 mg of PUFA/100g of sprout on an average.

The percentage of total PUFAs in seed were high (70.61%) to those of sprouts, while the percentage of linoleic acid (C18:2) was high in sprouts (19.51%) compared to seeds (17.7%). The linolenic acid (18:3) content was 4 percent more (52.85%) in seed compared to sprouts (48.8%). Flax seed was a rich source of linolenic acid (LA), containing over 50% of its fatty acids as α-linolenic acid (LNA), Omega-3 fatty acid (www.curezone.com). The ratio of PUFA/SFA in sprouts was high in Pembina (6.97%) and Linott (6.82%) compared to Rahab-94 (6.38%), but were relatively similar in values to those of seed (7.4%). Thus, the flax sprouts are the nutritionally valuable sourceproviding high contents of linoleic (18:2) and linolenic (18:3) acid and were in line with previous findings in canola and soybean sprouts (Bhardwaj & Hamama, 2009; Orhan et al., 2007).

Table 1. Major fatty acid composition of seeds and sprouts of three flax cultivars

Fatty acid and Oil Composition	Sprouts				Ground seed powder			
	Rahab 94	Linott	Pembina	Average (Sprout)	Rahab 94	Linott	Pembina	Average (Seed)
Oil %	14.9±2.81x	16.86±3.79x	15.9±1.46x	15.9	37.27±0.51x	33.38±0.04y	31.32±0.64y	33.99
Saturated FA								
C16:0	5.22±0.21x	5.22±0.47 x	5.00±0.20x	5.14	5.26±0.14x	5.27±0.01x	5.3±0.09x	5.28
C18:0	4.66±0.31x	4.13±0.44x	4.27±0.53x	4.35	3.92±0.41x	3.91±0.01x	3.98±0.37x	3.94
C20:0	0.31±0.02x	0.29±0.05xy	0.25±0.01y	0.28	0.15±0.02x	0.15±0.0x	0.16±0.01x	0.15
C22:0	0.44±0.04x	0.42±0.09x	0.33±0.02y	0.39	0.14±0.02x	0.13±0.00x	0.14±0.01x	0.14
Unsaturated FA								
C18:1	20.6±0.90x	20.33±0.33x	20.75±0.18x	20.56	19.61±0.67x	19.51±0.01x	19.60±0.67x	19.57
C18:2	20.0±0.51x	19.49±0.51xy	19.05±0.66y	19.51	17.75±0.37x	17.73±0.01x	17.81±0.18x	17.76
C18:3	47.8±0.96x	49.1±1.44xy	49.6±1.06y	48.8	52.88±1.03y	52.98±0.01xy	52.7±1.13x	52.85
C20:1	0.23±0.01x	0.23±0.01x	0.23±0.01x	0.23	0.22±0.01x	0.22±0.01x	0.22±0.01x	00.22
∑SFA	10.63±0.54x	10.06±1.05x	9.85±0.33y	10.16	9.47±0.40x	9.46±0.01x	9.58±0.30y	9.50
∑UFA	88.63±0.52x	89.15±1.16y	89.63±0.33y	89.1	90.46±0.39x	90.44±0.05x	90.33±0.31x	90.41
∑MUFA	20.8±0.91x	20.6±0.32x	20.98±0.18y	20.8	19.82±0.67	19.73±0.01	19.82±0.63	19.79
∑PUFA	67.8±1.41x	68.59±0.96xy	68.65±0.46y	68.31	70.63±0.84xy	70.71±0.01x	70.51±0.95y	70.61
∑PUFA / ∑SFA	6.38±0.46x	6.82±0.8y	6.97±0.28y	6.72	7.46±0.38x	7.47±0.01x	7.36±0.33y	07.43

Thevalues of oil and fatty acid compositions is the mean of three measurements as weight percent (wt %) total FAs from three replications and two experiments; Means with same letter (x/y) are not significantly different ($0.46<p>0.07$).

FA- Fatty Acid; ∑**SFA** - sum of saturated fatty acids (16:0+18:0+20:0+22:0);

∑**UFA** -sum of unsaturated fatty acids (18:1+18:2+18:3+20:1);

∑**MUFA** - sum of monounsaturated fatty acids (18:1+20:1);

∑**PUFA** - sum of polyunsaturated fatty acids (18:2+18:3).

Comparision of fatty acid and oil traits of flax sprouts with those of canola and soybean sprouts (Table 2) revelaed that Canola sprouts were high in contents for all the components analysed except for 18:3 (48.8%) and 18:2 (19.51 %), the proportions of fatty acids analysed on percent weight basis, showing the siginificance and impact of flax sprouts in nutrtion as dietary source. The reason for high levels of C18:3 in flax sprouts (48.8%) might be due to highest accumulation of γ- tocopherol at seed maturity (Herchi et al., 2011; Kamal-Eldin & Appelqvist, 1996) compared to those accumulated in canola seed.

Table 2. Comparison of fatty acid and oil traits of flax seed sprouts with those of Canola and soybean

Oil / FA composition*	Flax	Canola	Soybean
Oil%	15.9	27.33	0.03
Saturated FA			
C16:0	5.14	5.38	31.13±0.90
C18:0	4.35	1.21	1.80±0.03
C20:0	0.28	0.53	-
C22:0	0.39	0.27	2.27±0.36
Unsaturated FA			
C18:1	20.56	45.71	5.79±0.52
C18:2	19.51	18.35	15.27±1.09
C18:3	48.8	8.82	23.57±1.25
C20:1	0.23	7.44	-
∑SFA	10.16	7.54	35.2
∑UFA	89.1	92.46	44.63
∑UFA/∑SFA	8.77	12.26	1.27
∑PUFA	68.31	27.17	38.62
∑PUFA / ∑SFA	6.72	3.60	1.10
18:3/18:2	2.50	2.08	1.54

*The Oil and FA content were expressed in g/100g dry weight basis. The sprout data for canola and soybean was retrieved from peer reviewed publication of Bhardwaj and Hamama (2009) and Orah et al. (2007) for fatty acid profile comparisons.

4. Conclusion

Significantly low oil content in sprouts compared to seed and relatively similar fatty acid profiles for seed and sprout with equally potential values for essential fatty acid compositions (Omega 2 and 3) were observed in the study.The possible potential use of flax sprouts as supplementary dietary source to replace the different forms of flaxseed. Evaluations for seed sprouts to study the influence of seed maturity on fatty acid contents, tocopherols, sterols and other bioactive compounds will give better understanding of nutritional quality of sprouts. Analysis of sprouts from more cultivars including golden yellow seed will aid for future crop improvement for nutrition quality.

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